

AMENDMENT UNDER 37 C.F.R. § 1.111
U.S. Application No. 09/878,325

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (previously presented): A piezoelectric vibrator unit comprising:

at least one piezoelectric vibrator including:

common internal electrode layers and segment internal electrode layers arranged alternately;

piezoelectric layers, each interposed between adjacent pair of the common and segment internal electrode layers; and

external electrodes formed on an exterior of the piezoelectric vibrator and electrically connected respectively to the common internal electrode layers and the segment internal electrode layers; and

a fixing member to which a surface of the piezoelectric vibrator is fixed;

wherein the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction in which the internal electrode layers and piezoelectric layers are laminated; wherein a magnitude of electric fields applied between the common and segment internal electrode layers to the piezoelectric layers is non-uniform to cancel a bending moment caused during contraction of the piezoelectric vibrator.

2. (original): The piezoelectric vibrator unit according to claim 1, wherein the electric fields applied to the piezoelectric layers have respective, different magnitude.

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3. (original): The piezoelectric vibrator unit according to claim 1, wherein magnitude of an electric field applied to a piezoelectric layer located farther from a thickness center of the piezoelectric vibrator in the lamination direction is smaller than magnitude of an electric field applied to a piezoelectric layer located closer to the thickness center in the lamination direction.

4. (original): The piezoelectric vibrator unit according to claim 1, wherein as a piezoelectric layer is located farther from the surface fixed to the fixing member in the lamination direction, magnitude of electric field applied to the piezoelectric layer is smaller.

5. (original): A piezoelectric vibrator unit comprising:
at least one piezoelectric vibrator including:
common internal electrode layers and segment internal electrode layers arranged alternately;
piezoelectric layers, each interposed between adjacent pair of the common and segment internal electrode layers; and
external electrodes formed on an exterior of the piezoelectric vibrator and electrically connected respectively to the common internal electrode layers and the segment internal electrode layers; and
a fixing member to which a surface of the piezoelectric vibrator is fixed;
wherein the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction in which the internal electrode layers and piezoelectric layers are laminated;
wherein the piezoelectric layers are non-uniform in thickness.

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6. (original): The piezoelectric vibrator unit according to claim 5, wherein at least one of the piezoelectric layers, located away from the surface fixed to said fixing member, is thicker than other piezoelectric layers.

7. (original): The piezoelectric vibrator unit according to claim 5, wherein as a piezoelectric layer is located farther from the surface fixed to the fixing member in the lamination direction, the piezoelectric layer is thicker.

8. (original): The piezoelectric vibrator unit according to claim 5, wherein an outermost piezoelectric layer, located farthest from the surface fixed to the fixing member, is thicker than other piezoelectric layers.

9. (original): A piezoelectric vibrator unit comprising:
at least one piezoelectric vibrator including:
common internal electrode layers and segment internal electrode layers arranged alternately;
piezoelectric layers, each interposed between adjacent pair of the common and segment internal electrode layers; and

external electrodes formed on an exterior of the piezoelectric vibrator and electrically connected respectively to the common internal electrode layers and the segment internal electrode layers; and

a fixing member to which a first surface of the piezoelectric vibrator is fixed;
wherein the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction in which the internal electrode layers and piezoelectric layers are laminated;

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wherein parts of the external electrodes, located on a second surface opposite from the first surface, are thicker than other parts of the external electrodes.

10. (original): A piezoelectric vibrator unit comprising:

at least one piezoelectric vibrator including:

common internal electrode layers and segment internal electrode layers arranged

alternately;

piezoelectric layers, each interposed between adjacent pair of the common and segment internal electrode layers; and

external electrodes formed on an exterior of the piezoelectric vibrator and electrically connected respectively to the common internal electrode layers and the segment internal electrode layers; and

a fixing member to which a first surface of the piezoelectric vibrator is fixed;

wherein the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction in which the internal electrode layers and piezoelectric layers are laminated;

wherein the internal electrode layers are non-uniform in thickness.

11. (original): The piezoelectric vibrator unit according to claim 10, wherein at least one of the internal electrode layers, located away from a center line in the lamination direction, is thicker than other internal electrodes.

12. (original): The piezoelectric vibrator unit according to claim 10, wherein as an internal electrode layer is located farther from the surface fixed to the fixing member in the lamination direction, the internal electrode layer is thicker.

13. (currently amended): A piezoelectric vibrator unit comprising:

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at least one piezoelectric vibrator including:

common internal electrode layers and segment internal electrode layers arranged alternately;

piezoelectric layers, each interposed between adjacent pair of the common and segment internal electrode layers; and

external electrodes formed on an exterior of the piezoelectric vibrator and electrically connected respectively to the common internal electrode layers and the segment internal electrode layers; and

a fixing member to which a first surface of the piezoelectric vibrator is fixed;

wherein the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction in which the internal electrode layers and piezoelectric layers are laminated;

~~wherein a length of at least one of the internal electrode layers, located away from the surface fixed to the fixing member, is shorter than other internal electrode layers that are located between the at least one internal electrode layer and the first surface and that have the same polarity as that of the at least one internal electrode layer.~~

wherein an electric field applied portion of at least one of the piezoelectric layers, located away from the surface fixed to the fixing member, is shorter than other piezoelectric layers that are located between the at least one piezoelectric layer and the first surface.

14. (original): A piezoelectric vibrator unit comprising:

at least one piezoelectric vibrator including:

common internal electrode layers and segment internal electrode layers arranged alternately;

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piezoelectric layers, each interposed between adjacent pair of the common and segment internal electrode layers; and

external electrodes formed on an exterior of the piezoelectric vibrator and electrically connected respectively to the common internal electrode layers and the segment internal electrode layers; and

a fixing member to which a first surface of the piezoelectric vibrator is fixed;

wherein the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction in which the internal electrode layers and piezoelectric layers are laminated;

wherein the piezoelectric vibrator further comprises a bending moment adjustment member provided to a second surface of the piezoelectric vibrator, opposite in the lamination direction from the first surface fixed to the fixing member.

15. (original): A piezoelectric vibrator unit comprising:

at least one piezoelectric vibrator including:

common internal electrode layers and segment internal electrode layers arranged alternately;

piezoelectric layers, each interposed between adjacent pair of the common and segment internal electrode layers; and

external electrodes formed on an exterior of the piezoelectric vibrator and electrically connected respectively to the common internal electrode layers and the segment internal electrode layers; and

a fixing member to which a first surface of the piezoelectric vibrator is fixed;

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wherein the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction in which the internal electrode layers and piezoelectric layers are laminated; wherein a second surface of the piezoelectric vibrator, opposite from the first surface and located in a free end part of the piezoelectric vibrator, is entirely covered with the external electrode, and the first surface, located in the free end part, is partially covered with the other external electrode.

16. (previously presented): The piezoelectric vibrator unit according to one of claims 1, 5, 9, 10, 13, 14 and 15, wherein said at least one piezoelectric vibrator includes comb-like piezoelectric vibrators constructing a piezoelectric vibrator group.

17. (original): The piezoelectric vibrator unit according to one of claims 1, 5, 9, 10, 13, 14 and 15, wherein the piezoelectric vibrator further includes a non-active portion that is not expanded or contracted even when the piezoelectric layers in an active region are driven, and the fixing member is joined to a side surface of the non-active portion.

18. (original): An ink-jet recording head comprising:
a piezoelectric vibrator unit according to one of claims 1, 5, 9, 10, 13, 14 and 15; and
a flow passage unit having an elastic plate serving as a part of a seal member for sealing a pressure chamber communicated with a nozzle openings,
wherein said piezoelectric vibrator unit is attached by fixing a distal end face of the piezoelectric vibrator to the elastic plate.

19. (original): An piezoelectric vibrator unit comprising at least one piezoelectric vibrator, and a fixing member to which a first side surface of the piezoelectric vibrator at a base end thereof is fixed, the piezoelectric vibrator having, at least in part, a laminated structure

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including common and segment internal electrode layers laminated alternately with a piezoelectric layer interposed between each adjacent pair of the common and segment internal electrode layers, a first external electrode electrically conducted to the common internal electrode layers, and a second external electrode electrically conducted to the segment internal electrode layers, so that the piezoelectric vibrator is displaceable in a direction perpendicular to a lamination direction,

wherein the piezoelectric vibrator further includes a counterbalancing bending moment producing portion that produces a bending moment canceling a bending moment caused during contraction of the piezoelectric vibrator due to a structure in which the first side surface of the piezoelectric vibrator is fixed at the base end thereof to the fixing member.

20. (original): The piezoelectric vibrator unit according to claim 19, wherein the counterbalancing bending moment producing portion includes at least one piezoelectric layer which is located closer to a second surface, opposite from the first surface in the lamination direction, than to the first surface and which is thicker than other piezoelectric layers.

21. (original): The piezoelectric vibrator unit according to claim 20, wherein the at least one piezoelectric layer includes an outermost piezoelectric layer forming the second surface.

22. (original): The piezoelectric vibrator unit according to claim 20, wherein the at least one piezoelectric layer includes piezoelectric layers gradually increased in thickness in a direction from the first surface to the second surface.

23. (original): The piezoelectric vibrator unit according to claim 19, wherein the counterbalancing bending moment producing portion includes at least one internal electrode

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layer which is located closer to a second surface, opposite from the first surface in the lamination direction, than to the first surface and which is thicker than other internal electrode layers.

24. (original): The piezoelectric vibrator unit according to claim 23, wherein the at least one internal electrode layer includes internal electrode layers gradually increased in thickness in a direction from the first surface to the second surface.

25. (original): The piezoelectric vibrator unit according to claim 19, wherein the counterbalancing bending moment producing portion includes thick parts of the external electrodes, which are formed on a second surface of the piezoelectric vibrator opposite from the first surface.

26. (original): The piezoelectric vibrator unit according to claim 19, wherein the counterbalancing bending moment producing portion includes an bending moment adjusting member attached to a second surface of the piezoelectric vibrator opposite from the first surface.

27. (new): The piezoelectric vibrator unit according to claim 13, wherein a length of a pair of the internal electrodes applying an electric field to the at least one piezoelectric layer is shorter than other pairs of the internal electrodes applying electric fields to the other piezoelectric layers.
